Multi-scale structuring of enterprise's knowledge Towards an ubiquitous virtual assistant

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Abstract— **When the question about the "factory of the future" is discussed, it is often mentioned the use of innovative approach for knowledge acquisition and exploitation interfering in the different phases of the product lifecycle. Consequently, the use of innovative Knowledge Management Systems based on Information and Communications Technology (ICT) in the factory environment has become a must. Our research work will focus on the development of a "digital factory assistant" to help factory's actors in their daily tasks and in particular tasks that demand to make a decision.**

Keywords: Decision Support System, Factory of the future; Virtual assistant; Knowledge Management; Virtual Reality.

I. INTRODUCTION

Despite of the "Digitalization" of today's factory, either by the emergence of ICT, robots colonization, or by the use of advanced simulation that implements the new wave of virtual and augmented reality technologies, the human factor in today's factory is still vital. In the level of the production system, and when the employee have to act upon a task that demand decision making, he\she still in an uncertain context where the expertise level does not allow him/her to properly accomplish a task and make the right decision: what effort should he/she make? What is the right place to apply this effort? What are the consequences if he/she applies a choice?

In this context and to answer these questions, we introduce the concept of the "digital factory assistant". It consists of a smart agent based on an interaction between knowledge models and the entire factory's information system in order to provide the right information in the right time and place and for the right user. In addition, this assistant will extend the dimensions of interaction models by implementing virtual engineering technologies in order to properly represent the information and for a better reuse of the knowledge [1].

The first part of this paper presents the evolution made on decision support systems. In the second part we expose a state of the art in Decision Support Systems and data, information, and knowledge retrieval. After that, we expose the ARTUR project and present the idea about multi-scale knowledge structuring before we conclude.

II. EVOLUTION OF DECISON SUPPORT SYSTEMS

A. *Definition*

Basically, Decision Support Systems (DSS) are information systems with a high capability of reasoning in order to provide their users with a set of appropriate information. Shim [2] defines this concept as a set of computer technology solutions that can be used to support complex decision making and problem solving. Many other definitions of those systems were found in the literature. Definitions are highly related to the application field of decision support systems but they share a common aspect: DSS do not make decisions by themselves but attempt to automate several tasks of the decision making process. [3]

B. *Evolution of DSS*

Since the appearance of DSS, those systems evolved in a significant way, thinks to the parallel evolution made in information and communication technologies. From the technology implemented point of view, this evolution lead to the appearance of a new era of DSS like web-based DSS [4], Mobile DSS [5], Knowledge Based DSS [6], and ubiquitous DSS [7].

As showed in figure 1, types of decision support systems had moved from individual DSS to a new category of DSS called ubiquitous decision support systems (ubiDSS). The ubiquitous technology is a vision introduced by Weiser [8] in the end of 80s. It consists of a new model of interaction where the information processing is integrated in our daily life.

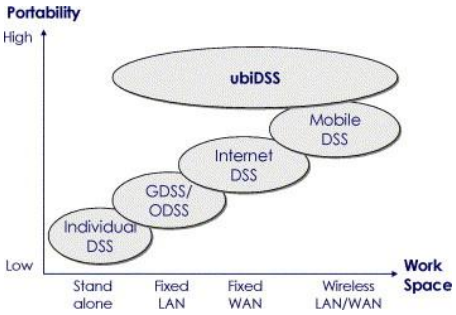

Figure 1. Evolution of Decision Supoort Systems [7]

The main idea of ubiDSS concept is the use of new ICT technologies that assure a high level of information and knowledge availability. Many works argue the use of this concept to build a DSS and the development of frameworks based on ubiDSS [7] [9] [10]. Even that many applications are built to validate those frameworks; few of them deal with industrial production domain. Our proposition is to move the application field of DSS to a "machine level" in production systems and combine it with knowledge based models. We believe that this field of application of decision support systems will lead to efficient product development by improving the effectiveness of employer's decision in the different phases of product lifecycle.

III. DATA, INFORMATION, AND KNOWLEDGE RETRIEVAL

Using advanced data management is a critical point to develop an efficient decision support system. In fact, due to the big evolution of digital tools in the industry, the output in terms of information is consequently the quantity of data and information manipulated in today's factory is growing. Consequently, forwarding the right set of knowledge to the right person who needs it becomes a crucial issue. In this section**,** we highlight the difference between Data, Information, and Knowledge and the retrieval systems related to each of them.

A. From Data to Wisdom: The DIKW hierarchy

In the literature review regarding knowledge Management, it was often highlighted the relation between data, information, and knowledge. The DIKW (Data-Information-Knowledge-Wisdom) hierarchy reflects this relation. It was first introduced by Ackoff [11] in 1988; he gave a hierarchical representation of the terms through the DIKW pyramid (figure 2). Since that, many authors have tried to describe more and more the relation between the different concepts in both Knowledge Management and Computer Science research field. [12][13] We will not discuss those prepositions in this paper but we will emphasize the difference between Data, Information, Knowledge, and Wisdom.

Figure 2. The DIKW hierarchy [11]

- Data: data can exist in any form and assumed to be simple isolated facts.[14][12]
- Information: information is data with a meaning.
- Knowledge: knowledge is information connected with relations.
- Wisdom: wisdom can be defined as putting into action accumulated knowledge

B. Data, Information, and Knowledge Retrieval

Many computer systems have been developed to manage data, information, and knowledge as has been seen in the previous section. Data Retrieval Systems like database management systems are well designed to manage and structure data. Information Retrieval Systems are designed to get relevant information and acquire more knowledge (web search engines). Also, Knowledge Retrieval Systems that support knowledge discovery, organization, and retrieval with the aim of providing knowledge to users in structured way.

Yao [15] define**s** in his work a conceptual framework of a knowledge retrieval system based on three main components: discovery of knowledge, construction of knowledge structures, and the inference of required knowledge.

Table 1 represents a comparison between data, information, and knowledge retrieval.

TABLE I. COMPARISON OF DATA, INFORMATION, AND KNOWLEDGE RETRIEVAL [15]

	Data retrieval	***Information Retrieval***	***Knowledge Retrieval***
Query	Artificial language	Natural language	Knowledge structure + natural language
Organization	Table, index	Table, index	Knowledge unit and knowledge structure
Storage	Database	Document collections	Knowledge base
Retrieved results	Data set	Sections or documents	A set of knowledge unit

In some practical situations like manufacturing systems, factory actors need to get information and to acquire knowledge to perform better in front of difficult tasks. The set of knowledge have to be presented in a structured way that a simple search engine, for example, cannot provide.

Région Pays de la Loire

The next section describe ARTUR project. Among the difficulties that this project aims to resolve is the difficulty of information/knowledge structuring in a Decision Support System for the purpose of a better reuse.

IV. ARTUR: TOWARD AN UBIQITIOUS DECSION SYSTEM

Related to visions of the factory of the future, the proposition of the project ARTUR is to offer the operator in the factory with a so called "Digital Factory Assistant". Through this assistant the operator can have information from distributed knowledge resources relying in different ways of interaction in order to act upon the task that he is doing. So, the main research issue of our work is to find which information to give to the operator, where, when, and how. The basic idea is to allow each person to be able to react in given situation, mainly thanks to high speed simulation and performance evaluation models and methods. [1][20]

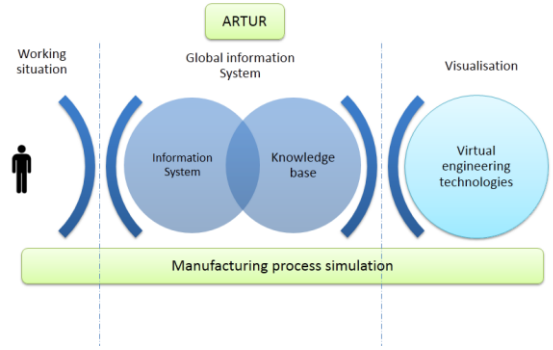

Figure 3. The different elements in ARTUR project

Project ARTUR deals with some particular aspects that other DSS seen in the literature does not treat:

- Modeling the interactions in the working situation: What are the different elements that the operator deals with in front of the machine and how they will be presented in the assistant? A particular interest will be given to the evaluation of human-machine interactions.
- Creating the ubiquitous environment: the ubiquitous environment will be created by the data flow coming from different resources of the information system in the factory including PLM systems, ERP, Cax models…
- Using Virtual Engineering technologies: this aspect is used in other decision support systems but the difficulty that we try to resolve is how to define new ways of interaction dedicated to non-specialized employers by extending the dimensions of Virtual Technologies models with further data sets.
- Coupling the information system in the factory with other knowledge models so the decision support aspect according to our proposition will be not disconnected from the information system in the factory.

Other particular aspect from those cited previously is the multi-scale knowledge structuring. This aspect will be more detailed in the next section.

V. MULTI-SCALE KNOWLEDGE STRUCTURING

As mentioned above, one of the main research propositions in the project ARTUR is the way of structuring the knowledge and information to be given to the operator.

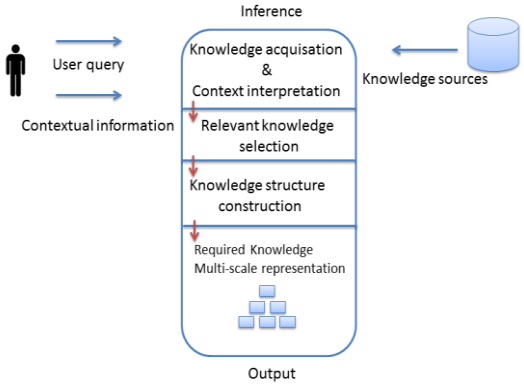

Figure 4. Conceptual vision of multi-scale structuring approach

Figure 3 illustrates a high conceptual level of our vision of multi-scale knowledge structuring. Taking into account decision support models, we aim to introduce a new way of definition, representation, and exploration of knowledge. We believe that the unit of knowledge should be presented to an operator in a multi-level structure where each level will be based on contextual set of information. Contextual information will be based on user profile: maturity level, knowledge already known, previous experience...

The relevant set of knowledge can be decomposed into hierarchical structure and represented in a multi-level way. According to his/her needs, the user will look for more granular set of knowledge that satisfies his/her query.

Some authors discuss the granularity of knowledge. [16][17]. March [18] [19] link the origins of knowledge granularity to three reasons: the multiple sources of knowledge, existence of different ways of knowledge representation, and the diversity of knowledge application domains.

Foundations of our research proposition relate to a new proposition for modeling and structuring information, and more generally knowledge. Consequently, dealing with the global data, information, knowledge and know-how, we will be able to contextualize reusing this knowledge in any given situation that would need this knowledge.

Our assistant will be based on a dynamic knowledge representation: In a process of decision making, the actor will combine different types of data and knowledge available in various forms [20].

CONCLUSION

In a production system, the user may be faced with working situations that require him/her to interact with the machine in front of him/her by choosing the right decisions. The decisions can be a force to be applied, a position of a tool in the machine… So, to make his/her decision the user will need to have such propositions of what he/she can do or what measure he/she will take and, using advanced simulation techniques, he/she can anticipate the influence of his/her choice.

To validate all those aspects in our project ARTUR, we will be based on two use cases in aeronautic industry. A survey will give us more detail on what elements in the factory's information system should interact with our assistant model and to identify the different knowledge sources and domains related to the executed process.

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